

Restoring Fire-Dependent Ponderosa Pine Forests in Western Montana

by Stephen F. Arno, Michael G. Harrington,
Carl E. Fiedler and Clinton E. Carlson

Looking for ways to
reverse the effects of
a century of fire-
suppression.

Many foresters and ecologists recognize that disruption of the historic pattern of frequent fires in ponderosa pine forests has resulted in major ecological changes, including increasingly severe wildfires and insect and disease epidemics (Weaver, 1943; Covington and Moore, 1992; Mutch and others, 1993; Everett, 1994). In response to this realization, there is increasing interest among natural resource managers, biologists, and the public in restoring ponderosa pine forests to more natural and sustainable conditions (American Forests, 1995). The Intermountain Research Station and the University of Montana's School of Forestry, in cooperation with the Bitterroot and Lolo National Forests have been testing the effectiveness of different silvicultural and prescribed-fire treatments for restoring ponderosa pine forests, and we will report some observations and initial findings here. But first we will summarize ecological changes that have occurred and describe our restoration treatments.

For thousands of years fire shaped the composition and structure of North American forests, favoring species such as ponderosa pine (*Pinus ponderosa*) that are fire-resistant and require fire to regenerate and compete successfully with other species (Pyne, 1982; Agee, 1993). In the inland West, pure ponderosa pine and mixed ponderosa pine-fir types are the most extensive of the fire-dependent forests. Non-fire-dependent species associated with ponderosa pine are interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), grand fir (*Abies gran-*

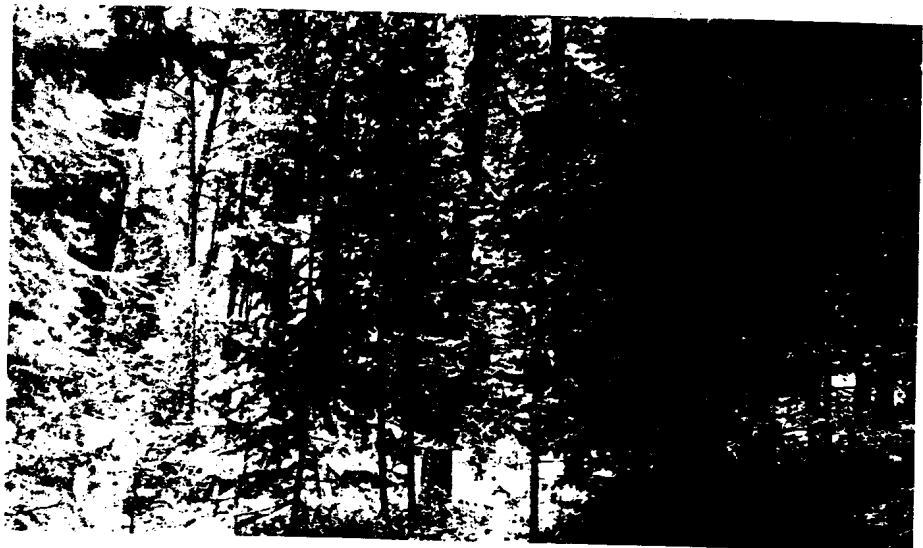
dis), white fir (*A. concolor*), and incense-cedar (*Calocedrus decurrens*). Pure and mixed ponderosa pine types cover about 40 million acres (16 million hectares) in the western United States, an area equal to that of the state of Washington (van Hooser and Keegan, 1988). Prior to the early 1900s these forests were characterized by frequent low- to moderate-intensity fires, mostly underburns that killed few overstory pines. Historically, fires at intervals averaging five to 30 years in most areas thinned small trees and helped produce open, park-like, fire-resistant stands (Arno, 1988). Today many of these forests have changed dramatically and are experiencing critical health problems as a result of 60-80 years of fire exclusion and logging of overstory pines. For example, more than a million acres in eastern Oregon's Blue Mountains now consist mostly of dead or dying trees, primarily fir thickets impacted by insect and disease epidemics (Mutch and others, 1993). Also, large stand-destroying wildfires, formerly rare in the open ponderosa pine forests, have become common in the dense stands that have developed as a result of fire exclusion. Dense stands also provide fuel ladders that cause fires to increase in intensity and climb into tree crowns. Severe fires in ponderosa pine made up a large portion of the three million acres that burned in the inland West during 1994.

Past logging, which selectively removed large pines and left understory trees has allowed rapid development of conifer thickets (Habeck, 1990). Extensive coni-

er understories have also developed in unlogged parks and preserves because of fire exclusion. If these areas should burn in a severe wildfire and no subsequent management activities occurred, they would be likely to re-develop into dense young stands with excess fuels from the fire-killed trees. Then these stands will become susceptible to another severe fire within a few decades (Arno et al., 1985).

The general goal of restorative management is to develop more open-stand structures consistent with historic disturbance regimes. It is usually necessary to begin restoration treatment in today's dense stands with a "low thinning" that removes excess understory and weaker overstory trees that cannot be safely killed in an underburn. Seral, disturbance-dependent ponderosa pine and western larch are favored for retention. These trees are fire-resistant and long-lived, commonly surviving 400 to over 600 years in conjunction with frequent underburns. Low-intensity prescribed fire is then conducted to reduce fuel loadings, kill excessive saplings, rejuvenate undergrowth (herbaceous and shrub species), and recycle nutrients in a manner similar to the natural fires of the past. Cutting without subsequent burning is ineffective for forest restoration because only fire can efficiently remove large proportions of the small understory trees (often thousands per acre) that occupy many stands and which, if not removed, will develop into thickets of stressed trees. In addition, fire produces unique changes in soil chemistry such as increased pH and rapid oxidation of nutrients, both of which may significantly influence nutrient availability.

Once thinning and burning are completed one can maintain some stands in natural conditions by periodic burning alone. However, over broader areas of the landscape it will be easier to maintain healthy, low-fire-hazard conditions using harvest techniques that include periodic thinning, retaining many of the dominant trees in addition to underburning. This approach encourages development of open stands with trees of many ages and sizes, which can be perpetuated in a healthy condition with selective cutting and underburning at intervals of about 15 to 30 years.



Decreasing frequency of fire in years following European settlement led to dramatic shifts in the composition of forest ecosystems in many forest ecosystems in the inland West. This sequence of photos documents replacement of fire-tolerant ponderosa pine by Douglas-fir on a site at the Bitterroot National Forest in Montana over a period of 40 years. Top to bottom: 1909, 1927, 1948. Photos courtesy of Steven F. Arno

Demonstration Studies

Our most extensive research/demonstration study is located in the Lick Creek area on the Bitterroot National Forest near Hamilton, Montana. Here we have established 33 research units of several acres each in which we are testing the restoration potential of different harvest treatments that leave a large proportion of the overstory pines followed by burning and "no burn" treatments (Fiedler et al., 1992). Cutting was designed to enhance the vigor of remaining trees and to rejuvenate undergrowth plants that are important as forage for wildlife. The accompanying set of photos illustrates the sequence of treatments from a photopoint within one of the harvest/burn units. Cutting reduced the basal area of the stand by about half.

Even though we believe that re-introduction of fire is crucial for maintaining sustainable natural stand structures, the kinds of fire needed for desired effects are not yet clear. Therefore, different burn prescriptions were tested, including burns in relatively moist, intermediate, and dry fuels, fuel-moisture stages which occur seasonally in this climate of wet winters and dry summers. We are also comparing the effects of spring and fall burning. A total of 15 units were underburned. All burns were effective in reducing potential for severe wildfires, and caused minimal mortality of overstory trees. An example of one of the restoration efforts being studied at Lick Creek is illustrated by a retention shelterwood cut and underburn treatment in a dense stand of 80-year-old ponderosa pine. The retention shelterwood design calls for thinning the overstory to reduce competitive stress while leaving shelter to encourage regeneration by natural or planted trees. The long-term goal is to create a multi-aged stand and to allow some of the overstory to reach an old-growth state. This stand was overstocked for a dry site, averaging 240 trees and 120 square feet of basal area per acre, 20 percent of which was Douglas-fir. The management plan prescribed harvest cutting to significantly reduce basal area, focusing on removal of the smallest merchantable pines and as many disease- and insect-prone firs as possible. The largest, most vigorous pines were retained, since they were a characteristic component of pre-1900 stands.



More recent photo-series documents treatment of a dense stand of ponderosa pine and Douglas-fir (top left) by harvest-cutting (bottom left), a spring underburn (top right), and one year of recovery (bottom right).

Total basal area was reduced to 48 square feet per acre, of which only 4 percent is fir. The smallest merchantable size class of pine (averaging 10 inches dbh) initially dominated the stand, and was reduced from 130 trees to about 40 trees per acre. The largest size class (greater than 17 inches dbh) decreased by only a few trees per acre. Seedlings and saplings—stress-prone, fire-sensitive firs or pines of poor

vigor in need of thinning—incur about a 30 percent density reduction from mechanical damage. The underburns were prescribed to reduce the fire hazard from existing and harvest-generated fuels (tree tops), reduce unsightly slash and barriers to movement of deer and elk through the stand, release nutrients bound in the organic horizons, and stimulate growth of herbs and shrubs. The initial focus was on



the fire hazard, which was represented in three strata of fuels. The top stratum was composed of interconnecting tree crowns, which allow a wildfire to spread rapidly through the overstory. This part of the hazard was greatly reduced by the harvesting operation, which left 10- to 20-foot gaps between adjacent trees. The middle stratum, commonly called ladder fuels, was made up of seedling and sapling conifers

which allow a fire to climb from the ground into the upper crowns. This hazard was reduced by the mechanical treatment. The third stratum, located on the ground where fires start and spread, consisted of litter, branch-wood, and downed tree trunks.

A reduction in the surface fire hazard with burning was realized by a 65 percent decrease in the initial 4.5 tons per acre of litter and small woody fuels and a 60 per-

cent reduction in the initial 5 tons per acre of large woody fuels. In addition to the reduction of ladder fuels in the harvesting process, a further reduction occurred with burning, which killed 60 percent of the seedlings and saplings. The average pre-harvest large woody-fuel loading of 5 tons per acre was increased by 2 to 3 tons with logging slash. Burning returned these fuels to approximately pre-harvest levels. These levels, while relatively low, may resemble presettlement conditions, when woody-fuel loadings were controlled by frequent surface fires.

Initially, understory vegetation was sparse and in poor vigor because of the dense overstory. Thinning and burning treatments have generally resulted in improved vigor and flowering of herbaceous plants in the first postburn year. Some alien herbaceous species have increased, and we are measuring their long-term trends. We suspect that small increases are inevitable with site disturbance, but that these can be minimized through use of low-impact harvesting equipment and techniques. In any case, the alternative of no management activity followed by severe wildfire can result in substantial increases in exotic plants.

Two shrubs important for wildlife browse are being monitored because of their decadent, pretreatment condition. Bitterbrush suffered 25 percent mortality from injury during harvesting and an additional 40 percent mortality from burning. Scouler's willow was reduced by 9 percent from mechanical damage and 16 percent more from fire. However, the surviving plants are substantially more vigorous, with greater live biomass and better palatability than unburned plants. The degree of utilization (browsing) by elk and deer indicates an obvious preference for sprouts of the burned willows. Other responses to silvicultural and fire treatments that are being studied include nutrient releases into the soil, organic matter decomposition rates, bird habitat, snag creation for cavity-nesting birds and mammals, and visual quality of the forest.

Another research/demonstration study at Sixmile Creek on the Lolo National Forest near Missoula, Montana, has a different theme. This study focuses on dense second-growth pine stands containing woodland

homes and developments, recreation areas, and scenic roadside corridors, all of which have high potential for severe wildfires (Scott, 1992). For example, more than 100 homes were burned in ponderosa pine forests around Spokane, Washington, during one firestorm in October 1991. The Sixmile Creek stand has received three contrasting treatments on adjacent 6-acre blocks in an effort to find ways to reduce fire hazard and improve stand health. One treatment is an economically-oriented thinning, which nevertheless retains esthetic values (tree tops and branches were hauled to a single large pile and burned). The second treatment is a low thinning (removing mostly the smaller trees) aimed at making the lightest possible visual impact, but also greatly reducing the risk of severe fire damage. Branches were burned in small hand-built piles, leaving little trace of char a year later. The third treatment represents an "ecological restoration," where low thinning was followed by an underburn. One year after the burn, a luxuriant undergrowth of grasses and herbs, including abundant flowering of arnica (*Arnica cordifolia*) and other species that seldom flower in untreated stands, attests to the stimulating effect of fire.

Additional demonstration studies of ponderosa pine forest restoration using silviculture and prescribed fire are being established. One is in an old-growth stand whose structure and current fire-free interval are far outside the historical range of variability. Another involves restoration of previously-logged stands once dominated by large ponderosa pine and larch but now consisting mostly of diseased fir thickets. Still another involves restoration of large ponderosa pine and larch along with seral riparian shrubs (important for wildlife habitat) along streamside habitats. Due to fire exclusion, these riparian areas are dominated by dense fir thickets with few shrubs or herbs. This demonstration study involves monitoring the effect of prescribed fire and thinning on both vegetation and water quality.

These studies will be used to evaluate the effectiveness of different restoration treatments. Field tours of both the Lick Creek and Sixmile study areas were conducted in 1994. Additional tours of the demonstration sites will be offered in 1995

and beyond. Anyone interested in attending is encouraged to contact the authors.

Conclusion

These studies demonstrate strategies for returning fire as an ecological process in ponderosa pine forests. Beginning a half-century ago (Weaver, 1943) several foresters and biologists presented detailed observations indicating that exclusion of fire from ponderosa pine forests would result in severe forest-health problems. Those warnings were largely unheeded, and even today fire is not being appropriately returned to these fire-dependent forests in most commercial stands or nature reserves. Meanwhile the deleterious effects of excluding fire without substituting appropriate cultural treatments, including prescribed burning, become more obvious with the passing years (Everett, 1994; American Forests, 1995). Restoring a semblance of the natural fire process in forests affected by fire exclusion requires considerable care and planning, but the technological knowledge to begin this restoration is available (see, for example, Kilgore and Curtis, 1987) and should be put to use. We hope our demonstrations will help encourage this endeavor.

REFERENCES

- Agee, J.K. 1993. *Fire ecology of Pacific Northwest forests*. Wash., D.C.: Island Press. 493 p.
- American Forests. 1995. Forest health and fire danger in inland Western forests: Proceedings of a conference; 1994 Sept. 8-9; Spokane, WA: Wash., D.C.: American Forests.
- Arno, S.F. 1988. Fire ecology and its management implications in ponderosa pine forests. In: Baumgartner, D.M. and Lotan, J.E. eds. *Ponderosa pine: the species and its management*; symposium proc. 1987 Sept. 29-Oct 1; Spokane, WA. Pullman, WA: Wash. State Univ. Coop. Extension publ.: 133-140.
- Arno, S.F.; Simmerman, D.G.; Keane, R.E. 1985. Forest succession on four habitat types in western Montana. Gen. Tech. Rep. INT-177. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 74 p.
- Covington, W.W.; Moore, M.M. 1992. Postsettlement changes in natural fire regimes: Implications for restoration of old-growth ponderosa pine forests. In: Kaufmann, M.R.; Moir, W.H.; Bassett, R.L. tech. coordinators. *Old-growth forests in the Southwest and Rocky Mountain Regions*; Proceedings of a workshop. 1992. March 9-13; Portal AZ. Gen. Tech. Rep. RM-213. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 81-99.
- Everett, R.L. compiler. 1994. Restoration of stressed sites, and processes. Gen. Tech. Rep. PNW-GTR-330. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 123 p.
- Fiedler, C.E.; Arno, S.F.; Carlson, C.E.; Harrington, M.G. 1992. Management prescriptions for restoring biodiversity in Inland Northwest ponderosa pine-fir forests. *The Northwest Environmental Journal* 8(1):211-213.
- Habeck, James R. 1990. *Old-growth ponderosa pine-western larch forests in western Montana: ecology and management*. *The Northwest Environmental Journal* 6(2):271-292.
- Kilgore, Bruce M.; Curtis, George A. 1987. *Guide to understory burning in ponderosa pine-larch-fir forests in the Intermountain West*. Gen. Tech. Rep. INT-233. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 39 p.
- Mutch, R.W.; Arno, S.; Brown, J.; Carlson, C.; Ottmar, R.; Peterson, J. 1993. *Forest health in the Blue Mountains: A management strategy for fire-adapted ecosystems*. Gen. Tech. Rep. PNW-310. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 14 p.
- Pyne, S.J. 1982. *Fire in America: A cultural history of wildland and rural fire*. Princeton, NJ: Princeton University Press. 654 p.
- Scott, J.H. 1992. Reducing forest fire hazard in residential and scenic areas: a case study comparing three treatments in a western Montana ponderosa pine stand. Study Plan RJVA-92685, Intermountain Research Station/University of Montana, Missoula, MT. 30 p.
- van Hooser, D.D.; Keegan, C.C. III. 1988. Distribution and volumes of ponderosa pine forests. In: Baumgartner, D.M.; Lotan, J.E., eds. *Ponderosa pine: the species and its management*; symposium proc. 1987 Sept. 29-Oct. 1; Spokane, WA. Pullman, WA: Wash. State Univ. Coop. Extension publ.: 1-6.
- Weaver, H. 1943. Fire as an ecological and silvicultural factor in the ponderosa pine region of the Pacific slope. *Journal of Forestry*. 41:7-14.

Stephen F. Arno and Michael G. Harrington are research foresters and Clinton E. Carlson is a research silviculturist with the Intermountain Research Station, USDA, Forest Service, Missoula, MT 59807. Phone (406) 329-4800. Carl E. Fiedler is a research assistant professor at the School of Forestry, University of Montana, Missoula, MT 59812. Phone (406) 243-5602.